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ABSTRACT

Innovation includes not only the production of new technology but also its use. From the user's perspective several stages are indicated including acquiring initial awareness of the new technology, deciding about its merit, adopting, implementing and deploying, and eventually establishing routine use. This process is longitudinal, involving units of analysis at different levels of social aggregation: the multi-level problem demands conceptual stretching of discipline-bound research. Psychology has been only peripherally involved in innovation research. Applied psychologists have been concerned primarily with individuals in limited social contexts over short periods of time. Psychology can offer some strengths in furthering the understanding of issues such as innovation and productivity. On-going field experimentation could dramatically increase the ability to influence technology change. The potential strengths of psychology to increase understanding of innovation--measurement rigor and experimentation--may be offset by its epistemological blockages. As long as psychology remains wedded to the individual as the unit of analysis, preoccupied with short-term phenomena, it will fail to realize its potential in the field of innovation research and in the solution of contemporary social problems. (JAC)

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Research on Innovation:

Stretching the Limits of the Discipline

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Research on Innovation:

Stretching the Limits of the Discipline

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My intent today is not to discuss substantive findings in innovation research. Those of you who are interested in such a grand view may receive a copy of the 264 page Literature Review that my Section at the National Science Foundation has recently published (Tornatzky, Eveland, Boylan, Hetzner, Johnson, Roitman, and Schneider, 1983). Rather, I would like to juxtapose the phenomena of innovation against the conceptual and methodological framework of comtemporary psychology. One purpose of this exercise is to help understand why psychologists and psychology have been only peripherally involved in research on innovation. A second not-so-hidden purpose is to influence the discipline to case off its epistemological shackles and move into research areas, such as this one, that have both theoretical richness and social relevance.

Let me first sketch in the prevailing descriptive view of how innovation occurs. The most pervasive organizing schemes in the field have rested on two main premises:

1) Innovation is a process of many discrete decisions and behaviors that unfolds slowly over time, and generally proceeds through a series of stages of activity;
2) Innovation involves social units at many different levels of aggregation, including individuals, groups, organizations, singly and in combination.

To illustrate these basic concepts, let me describe a simplified, scenario. Let us assume that once upon a time a researcher, or group of researchers, in a university materials science department made a series of important empirical and conceptual advances. We should, of course, note that the success of this work was colored by the personalities and individual characteristics of the members of the research team, the management and incentive structure of the academic department, and the supportive milieu of the larger university organization. It may also have been influenced by prior or current relations with industrial organizations, such as via consulting or contract research.

Let us further optimistically assume that the basic research knowledge got "transferred," or transformed, to a more applied or developmental setting. One can visualize a small R&D team creating the next generation of electronic device in some bit of corporate America, partly using the basic science from the university, but more significantly adding months and years of their own efforts. We should also note that the R&D group is embedded in a larger corporate setting, with its own organizational structure, incentives and decision processes that impinge on the group and its constituent members' behavior. They will need to coordinate their activities with marketing, production, and strategic planning functions of the firm, will need to fight for resources, and will need to manage their own internal social processes.

If the group is lucky and skillful they may give birth to a prototype for a new product or process. However, the subsequent probability of achieving success in full-scale marketing or diffusion will depend upon a number of other variables both internal to the firm and operating in the larger environment. These might include the structure of the industry in

which the firm is located, the state of the economy, the slack resources available in the firm for fine-tuning the product, the strategic plan of the company, and so on.

It should also be realized that this bringing-to-market analysis of innovation has only included those actors and stages involved in producing the new technology. At this point an entirely different set of actors come more actively into play -- the users of the innovation. These are the individuals and/or organizations that adopt and deploy the new technology.

From their perspective there are another set of stages and processes that are gone through. These include acquiring initial awareness of the new technology, deciding about its merit, perhaps purchasing or adopting, implementing and deploying, and eventually making the new into the not-new through routinization. Just because a technology is good does not imply that adoption-implementation proceeds smoothly; there are many variables that affect the process. These include characteristics of the innovation, characteristics of the users, tactics of dissemination, decision processes within the adopting organizations, and so on.

Maybe, after ten or twenty years of elapsed time, this scenario will result in a new industrial thrust in the American economy -- in short, a bona-fide technological innovation, widely diffused throughout the social system and involving a complex network of producers and users.

Abstracting ourselves from this scenario what we are confronted with is an intertwining of activities of mind-boggling complexity. It is also a set of social phenomena that is not well understood either conceptually or empirically, and which has not yielded to the efforts of social science research. Several themes in my description have clear research design implications for advancing that understanding.

For example, the process is obviously longitudinal. Any research that hopes to capture the phenomena in a meaningful way must have a time frame of years. For example, a project that I directed which studied only one slice of the overall process, the dissemination of a treatment innovation to mental hospitals, was a four year effort. (Tornatzky, Fergus, Avellar, and Fairweather, 1980). The BAM project which you will hear described today was of similar scope and duration.

At the risk of being redundant, I will again emphasize that the innovation process is one that involves units of analysis at different levels of social aggregation. These include individuals, groups, organizations, and entire industries. The "nestedness" of the phenomena must be acknowledged in any research that hopes to unravel its processes. There is much opportunity for committing the "ecological fallacy," that is, making inappropriate inferences from one level of analysis (such as the individual) to another (such as the group).

Not only is the multi-level problem an statistical-analytic issue, it also demands conceptual stretching of discipline-bound research (see Roberts, Hulin, and Roesseau, 1978). Theory construction in the social sciences has rarely developed schema which can capture phenomena occurring simultaneously at different levels of social aggregation. Theory has become a series of mini-theories, with an emphasis on one unit of analysis as the focus of scrutiny. In psychology this has been the person in a social setting; in sociology the group or organization largely abstracted from the person and the socio-economic surrounding; in economics the firm or industry operating in a market context; in political science the dynamics of power and political interests. The limitations of an exclusive preoccupation with any one of these orientations should be obvious. One person's error variance is another person's meat and potatoes.

It is worth noting here the topics and methods that the applied branches of psychology have settled on. I am referring to social psychology, community psychology, industrial-organizational psychology, and, of course, clinical psychology. Without doing too much violence to these fields, it is fair to say that the applied psychologies have been concerned primarily with individuals, in limited social contexts, over short periods of time, and with "mental-healthy" types of issues. To illustrate, consider a review by John Lounsbury and his associates (Lounsbury, Leader, Meares & Cook, 1980) of the community psychology field. Their content analysis of 478 articles published between 1973 and 1978 indicated "a concentration on psychological constructs and variables measured at the level of the individual." Sociological or organizational variables were a distinct minority. My own, less systematic, review of journals such as American Psychologist, Journal of Personality and Social Psychology, and Journal of Applied Psychology yields a similar picture. Psychologists have become micro-level social scientists, looking at individuals and examining individual-level variables.

For those of you who are inclined to believe that such has always been the case in psychology, may I remind you of the early, perhaps "golden," years of social psychology. A perusal of the 1958 edition of Maccoby, Newcomb, and Hartley, Readings in Social Psychology, is instructive. Here we found experimental and non-experimental studies in which individual, and group, and social systems were the foci of analysis. Some of you may remember studies of democratic versus authoritarian social systems, studies of interracial housing, an analysis of an invasion of men from Mars, and so on. While there were methodological problems in some of this earlier work, problems which have been "solved" by a greater concentration on highly-structured laboratory-based work, one wonders whether the cure has been iatrogenic.

Let me now shift my discussion a bit, and concentrate on the potential strengths that psychology has to offer in furthering the understanding of issues such as innovation and productivity. I see them as twofold: 1) a long tradition of operational precision in the measurement of slippery concepts; 2) an understanding of, and experience in, social experimentation.

One of the negative aspects of the interdisciplinary approach to the study of innovation has been the confusion in, and overpopulation of, explanatory constructs. Rogers and Shoemaker (1971) -- a dated but still a classic reference in the field -- cite 2,297 studies relative to their 103 generalizations about the diffusion of innovations. Zaltman and Duncan (1977) enumerate 178 "general principles" dealing with the innovation process. Similarly, the field of organizational behavior, which plays an important role in understanding innovation in an organizational setting, cuts across several academic disciplines and has a plethora of concepts for what simple observation would suggest are the same phenomena. Obviously, unifying concepts that number into the hundreds are not unifying concepts.

One rather obvious solution to this situation would be to replace theoretical uncertainty with operational specificity. One of the greatest needs in the innovation field is to reduce redundancy by precise measurement. For example, there is a large literature on perceived characteristics of innovations and their relationship to innovation adoption-implementation (e.g., Tornatzky and Klein, 1982). Literally dozens of ostensibly independent and distinctive characteristics have been studied. Whether this apparent multiplicity of variables would boil down to a more manageable number when subjected to multivariate analytic techniques remains an empirical question. Other similar problems in the innovation field could yield to hard-nosed measurement and statistical rigor -- and psychologists could be indispensible in this effort. Thus far they have not been so involved.

A second major, but only potential, contribution that psychology is capable of would be in bringing real-time field experimentation to the study of innovation. As I have described it, innovation is an active and dynamic process that occurs over time. The dominant paradigms in understanding this unfolding have been either retrospective analysis or passive case study observation. A common approach has been is to treat every setting as irretrievably unique and to employ qualitative methodology. Some have argued (e.g., Downs and Mohr 1976) that generalizable findings about innovation are difficult or impossible, and case study advocates have suggested that it is too difficult to study innovation using other than qualitative methodology. There have been very few studies in which variables have been explicitly manipulated, in the experimental tradition, and changes in innovation behavior documented. My own work in mental hospitals (Tornatzky, Fergus, Avellar, and Fairweather, 1980), the BAM project, work by Judith Larsen (Larsen, Norris, and Droll, 1976), and Edward Glaser are notable exceptions. (Incidentally, these notable exceptions all involved psycholgists as principal investigators).

There are some obvious advantages to real-time experimentation. One of the obvious is the gain in inferential power. Less obvious is the gain in timeliness in the ability to influence the innovation process in the society. This latter benefit has important implications for the public policy aspects of technological innovation and industrial productivity. Our nation is now involved in an intense struggle with foreign competitors in several important technological areas. To the extent that we can better understand the innovation process, and feed back that increased understanding while the process is still underway, we will gain much. Ongoing field experimentation could dramatically increase our ability to influence technological change. The best way to understand the causal effect of a variable on the innovation process is to change that variable and see what happens.

By way of illustration let me discuss two research issues in the innovation field in which a "stretched" discipline of psychology could contribute. These are, respectively, the problems of: 1) implementation of new technology; and 2) university-industry relations.

One outmoded tradition in the innovation field has been to focus on the adoption of new technology, and to ignore the distinction between adoption and implementation. It has been assumed that once a technology is decided upon or purchased, then the process of deployment is inevitable. However, recent findings indicate that what happens after initial adoption of technology, as innovations are introduced into the flow of work in an organization, is crucial to our understanding of innovative activity and of the diffusion of innovations across sectors or industries.

Available data on implementation also suggest that the importance of the implementation-adoption distinction is contingent upon the nature of the innovation. For example, it still might be acceptable to speak of simple adoption when considering "plug-in" technology. However, when the technology is complex and involves major dislocations in organizational and social aspects of the adopting site, then implementation becomes even more an issue. For example, office automation and integrated manufacturing systems are highly complex technologies that involve both machine and social-organizational aspects as critical elements (e.g., Bikson, Gutek, and Mankin, 1981).

For those of you who have not seen a newspaper for the past year, I should note that as we meet today the nature of factory life and production systems is being irretrievably transformed. Robotics, computer assisted manufacturing, and flexible manufacturing systems are being purchased, and, more important, being implemented through a long trial and error process. The social experiments are already underway; they are just uncontrolled,

unmonitored, and data-free from the perspective of social science. A series of longitudinal field experiments involving vendors and users, management and labor, and which would compare implementation approaches is acutely needed by the country.

Similarly needed is an explicitly experimental approach to designing the university-industry interface. Innovation is almost always a process where there are important inter-organizational transactions of knowledge, such as those involving universities and industrial firms. Unfortunately this activity is not well-grounded empirically or conceptually, although there have been attempts to apply the general literature on interorganizational relations to the problem. However, this work has rarely focused on technological change as dependent variables, and has usually been preoccupied with how to achieve "coordination" among, health and human service agencies. The literature that does exist on university/industry technological interaction has been generally limited to case studies and anecdotes of "success".

As any of you in universities know, here too the non-experimental "experiments" are already underway. University vice presidents for research are in an experimenting mood these days, with increasing pressure to replace declining Federal dollars with other sources of research funding. Again, real-time, well-instrumented attempts to systematically intervene in the unstructured, uncertain field of university-industry relations could yield untold benefits in better harnessing the nation's intellectual capital.

Let me close by reiterating the themes I struck at the beginning. The potential strengths of psychology to increase understanding of innovation -- measurement rigor and experimentation -- may be offset by its epistemological blockages. As long as psychology remains wedded to the individual as the

unit-of-analysis and preoccupied with short-term phenomena, it will fail to realize its potential in the field of innovation research, and in the solution of other contemporary social problems. Some would argue that what I am suggesting is beyond the limits of the discipline. However, if we stretch our definition of what is permissible and valued psychological inquiry, the problem becomes a non-problem.

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